

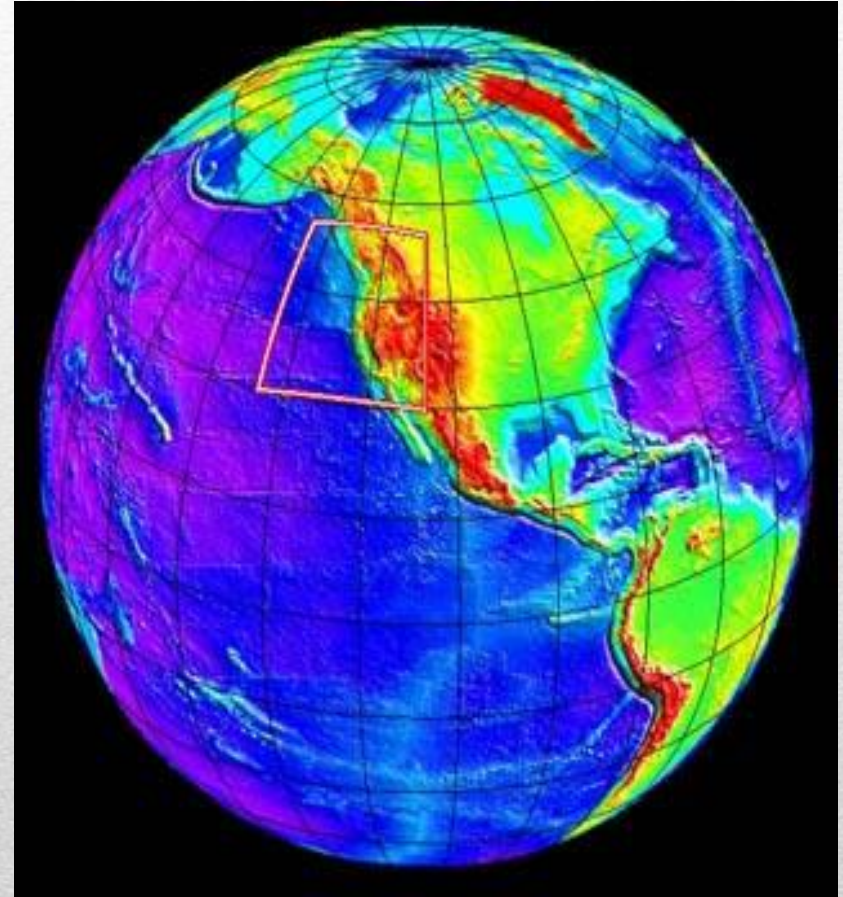
# **Internal Structure of Earth and Plate Tectonics**

## **Chapter 2**

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# The Internal Structure of Earth

- The Earth is a complex dynamic planet
- The Earth has a rigid outer shell, a solid center, and a thick layer of liquid that moves around as a result of dynamic internal processes
- The internal process are responsible for the effecting the surface of the earth

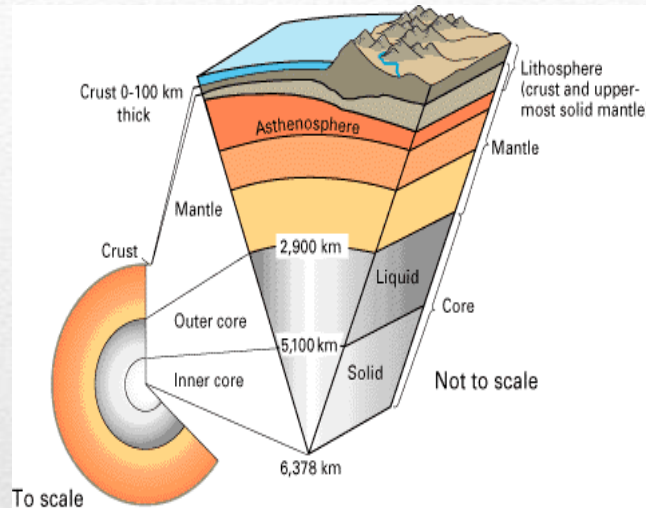




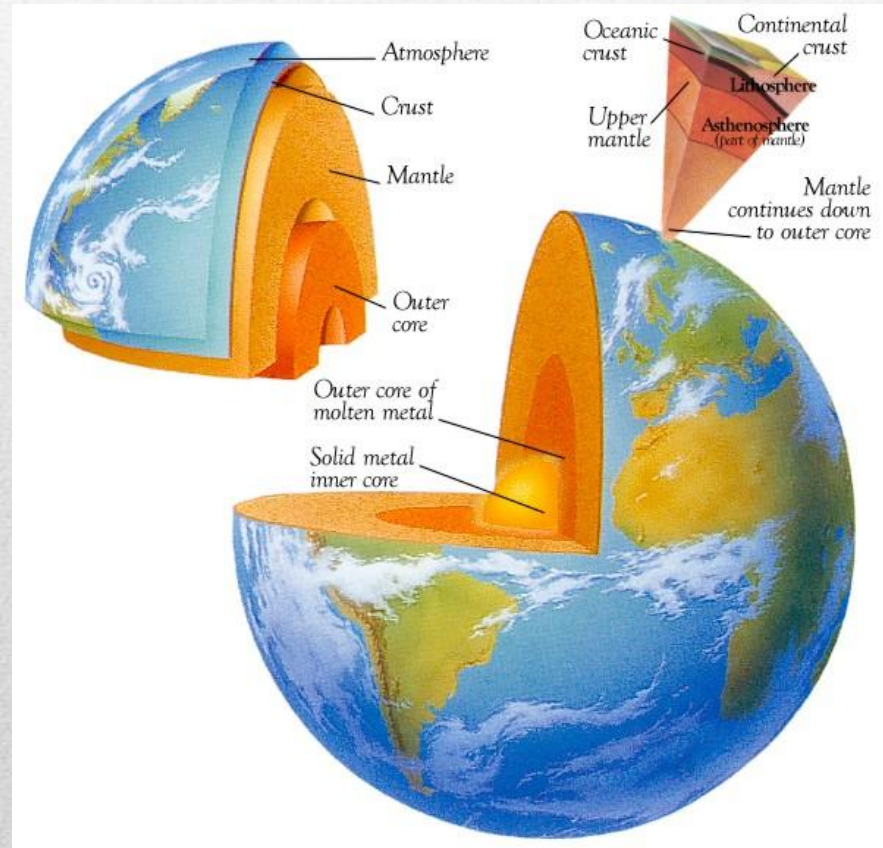
# To analyze topography answer these questions

- **What?** The form of the feature or features
  - **Where?** The distribution and pattern of the landform assemblage
  - **Why?** An explanation of origin and development
  - **So what?** The significance of the topography in relationship to other elements of the environment and to human life and activities
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# The Earth is Layered and Dynamic



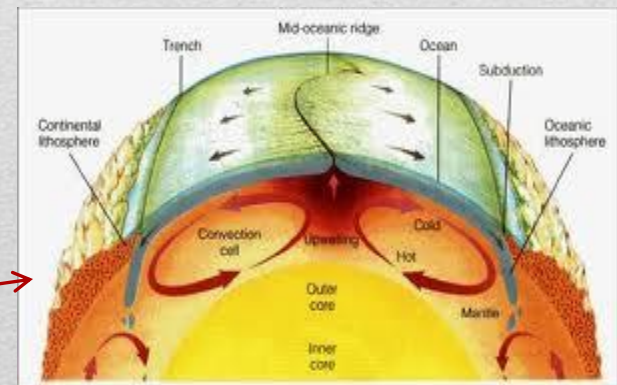
- **Four Regions**
  - The Crust
  - The Mantle
  - The Outer Core
  - The Inner Core





# The Earth is Layered and Dynamic

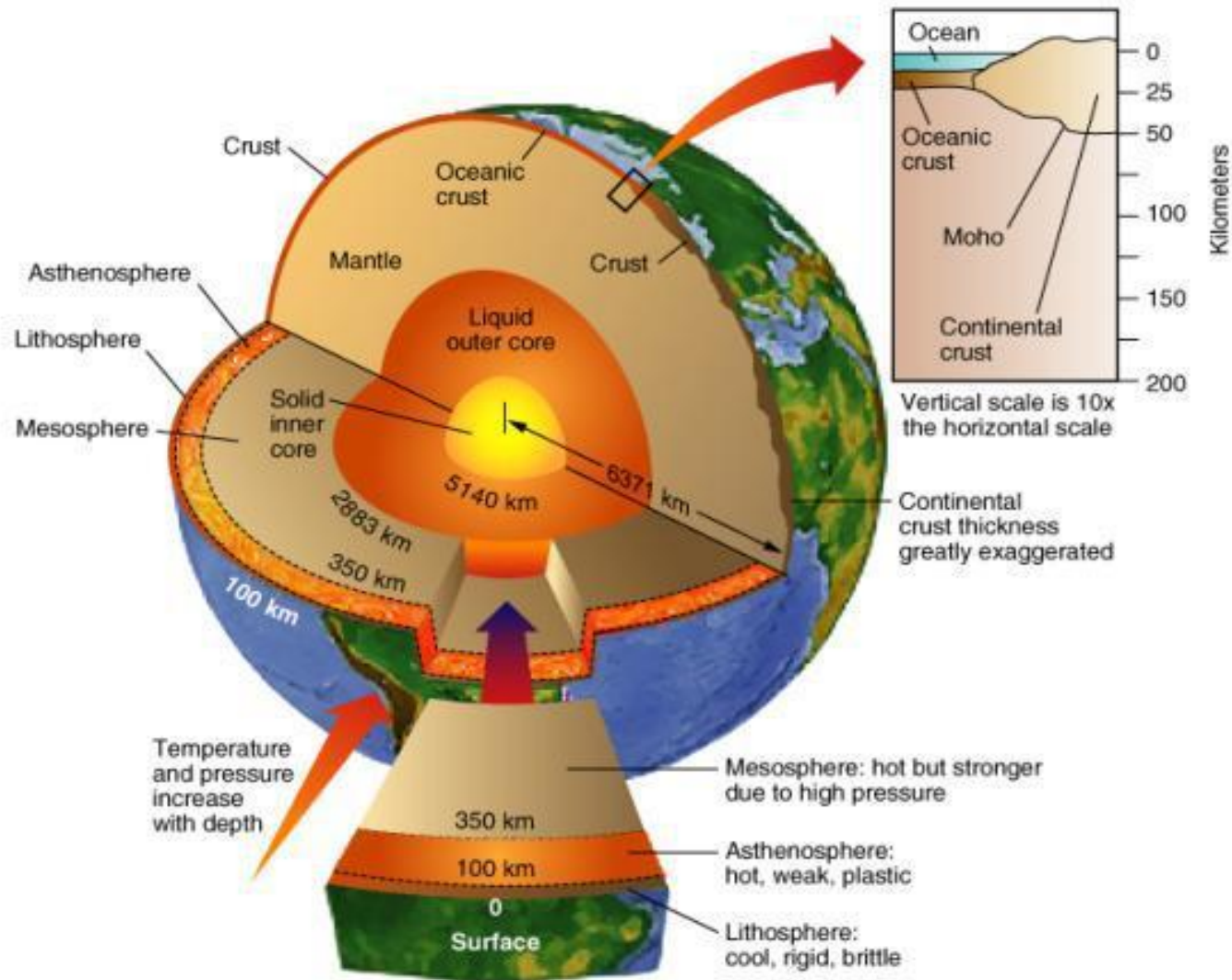
- The Inner Core
  - Solid and very dense mass having a radius of 808 miles
  - Both the inner and outer core are made of **iron/nickel or iron/silicate**.
  - Makes up **15% of the Earth's volume and 32% of its mass**
  - The Earth's **magnetic field is generated primarily in the outer core**
  - Magnetic field changes over time from North Pole to South Pole
- The Outer Core
  - Molten and extending to a depth of about 1243 miles
  - These is where the convection happens



# The Earth is Layered and Dynamic

- Above the Inner Core is the Mantle (1864 miles) is a change in mineral composition, called
    - The Crust sits on the Mantle where convection takes place moving the plates
    - Between the Mantle and the crust is the Mohorovicic discontinuity (or Moho)
  - The outermost hard hell, consists of a broad mixture of rock types
  - This is called the Lithosphere (from the Greek word for rock)
    - Average thickness averages 3 miles, between continental and ocean crusts
    - The continents' crust averages more than 5 times that of the oceans crust
-



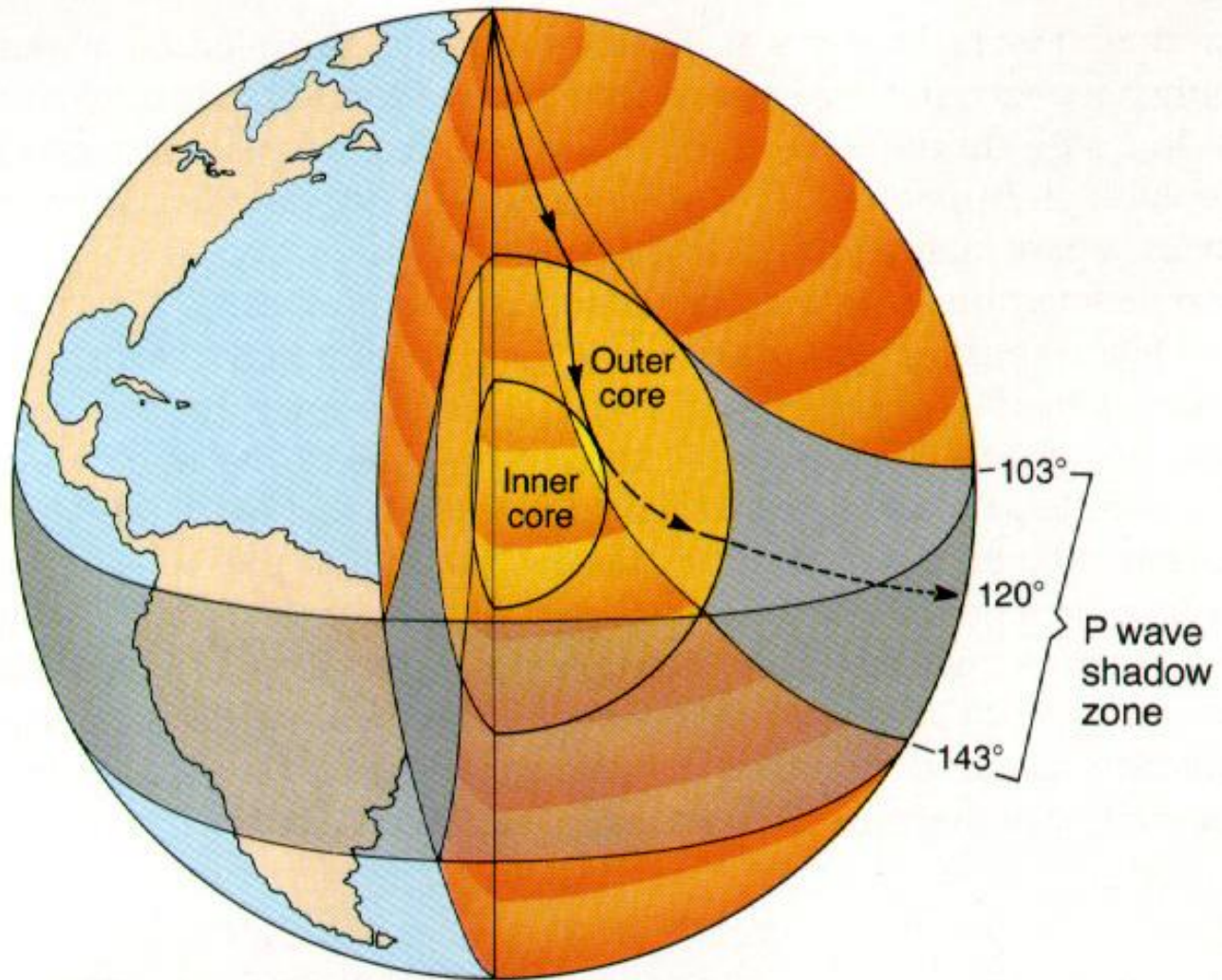


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# How Do We Know About the Internal Structure of Earth

- What We have learned about Earth from Earthquakes
    - Though the study of **Seismology** we have learn about the structure of the Earth.
    - Seismology is the study of earthquakes and the passage if seismic waves through the earth
    - These waves are called P waves and S waves
      - These waves travel through the earth at different rates
      - It is been through the study of the travel of these waves that Seismologists have been able to describe the center of the earth.
  - These studies have been able to determine
    - Where magma is generated in the asthenosphere
    - The existence of slabs of lithosphere that have apparently sunk deep in the mantle
    - The extreme variability of lithospheric thickness, reflecting its age and history
-





# Internal Geomorphic Processes

- Crustal rearrangement (plate tectonics)
    - Folding
    - Faulting
    - Uplifting
    - Earthquakes
  - Volcanism
    - Extrusive
    - Intrusive
-



# External Geomorphic Processes

- Atmosphere and Severe Weathering
  - Tsunamis
  - Flooding
  - Mass Wasting
  - Subsidence and Soils
  - Atmosphere and Severe Weather
  - Hurricanes and Extratropical Cyclones
  - Coastal Hazards
  - Climate and Climate Change
  - Wildfires
  - Study of these processes Uniformitarianism
-

# Geologic Time

- Earth is about 4.6 billion years old
  - Age of the dinosaurs 160 million years ago
  - Rocky Mountains uplifted 65 million years ago
-

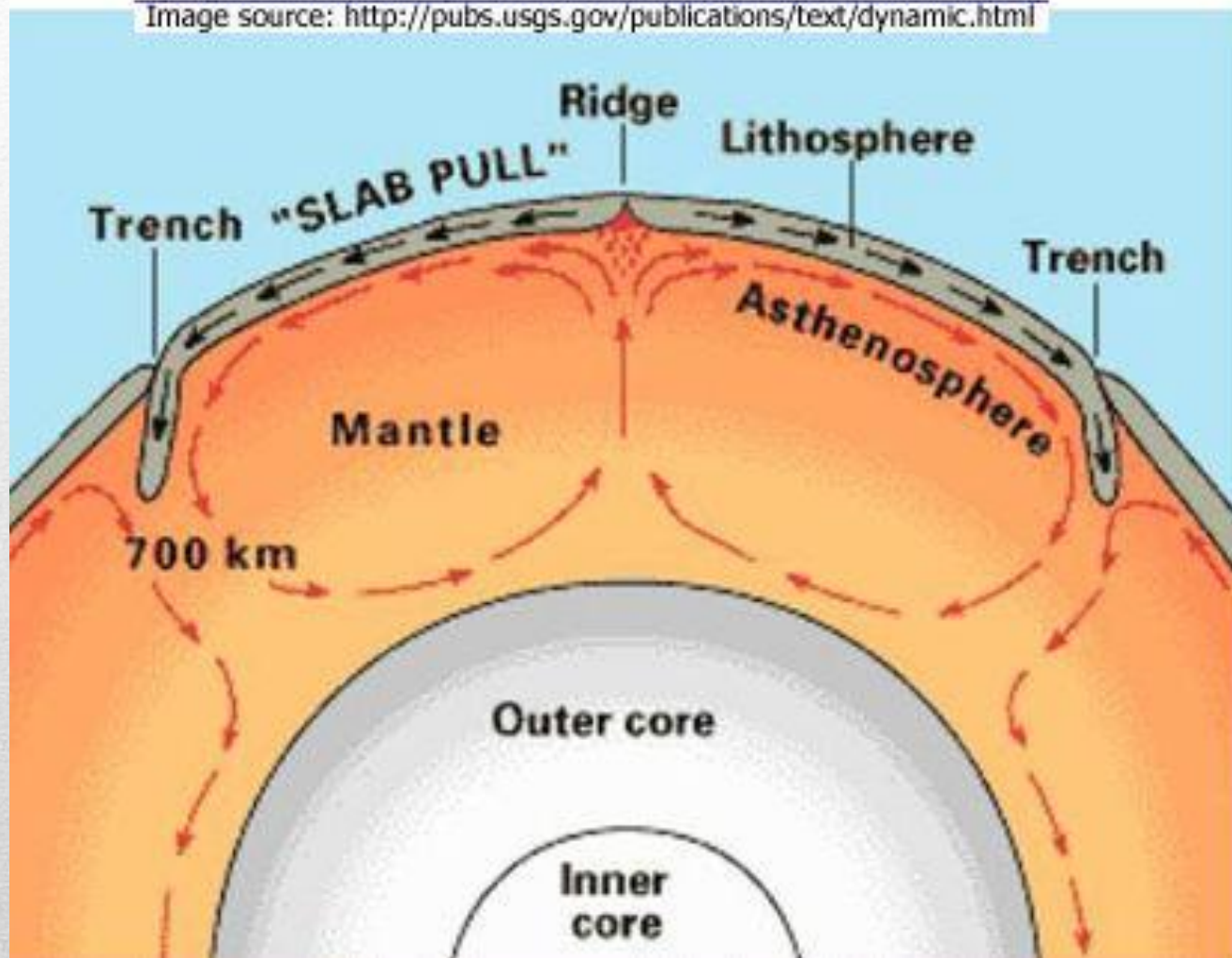


# Plate Tectonics

- The term *tectonics* refers to the large-scale geologic processes that deform the Earth's lithosphere.
  - Movement of the lithospheric plates
    - What is Plate Tectonics???
    - Processes associated with creation, movement, and destruction of the *lithospheric plates* collectively is called plate tectonics
-

## The Forces That Cause Plate Tectonics

Image source: <http://pubs.usgs.gov/publications/text/dynamic.html>



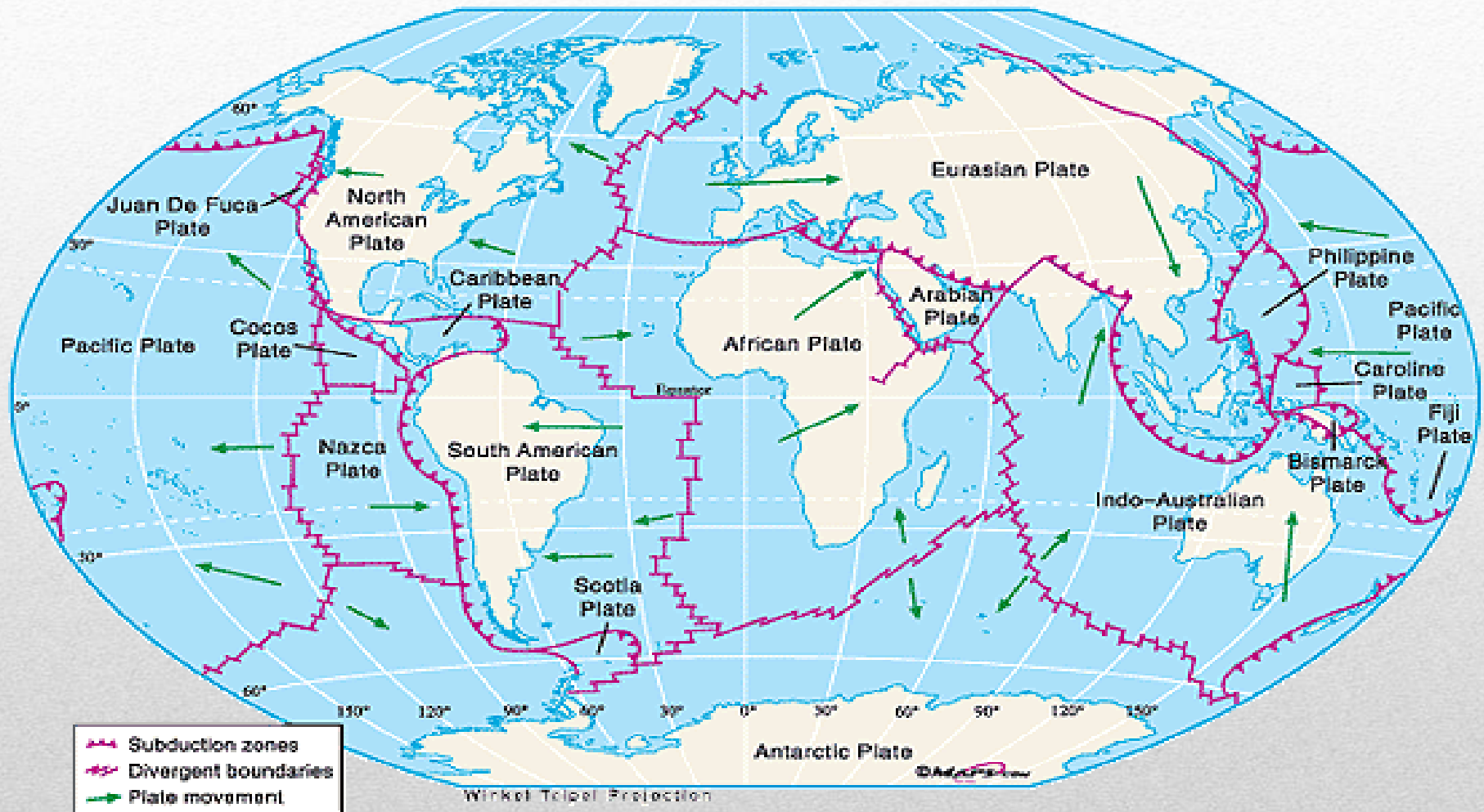


# Plate Tectonics

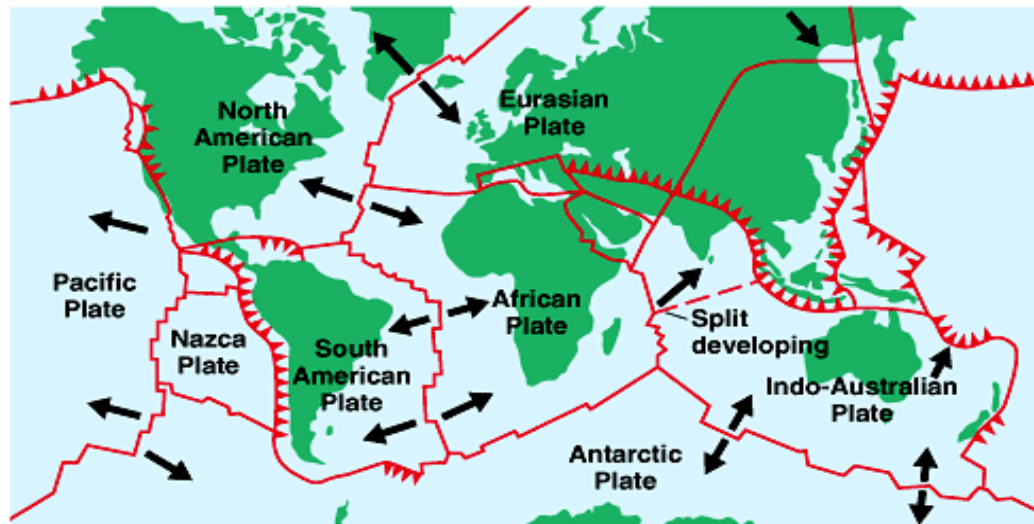
- Locations of earthquakes and Volcanoes Define Plate Boundaries

- Plates may include both a continent and part of an ocean basin or an ocean region alone.
  - Some plates are very large, some are very small, are relative to their location.
  - Most earthquakes and volcanoes are associated with the interactions of the plate boundaries, mostly defining where they are
  - Over the geologic time, plates are formed and destroyed, cycling materials from the interior of the Earth to the surface and back again
  - This is the tectonic cycle
-

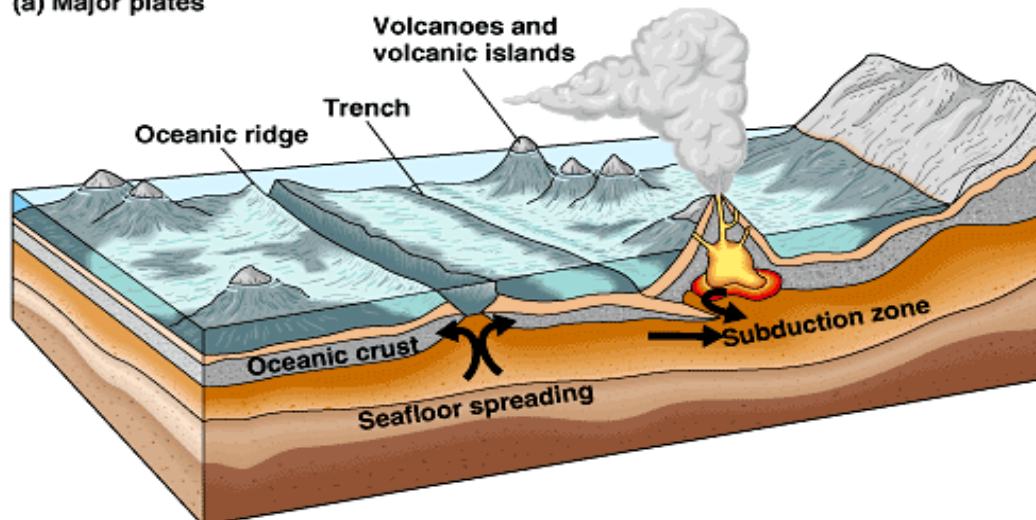
## Earth's Tectonic Plates







(a) Major plates



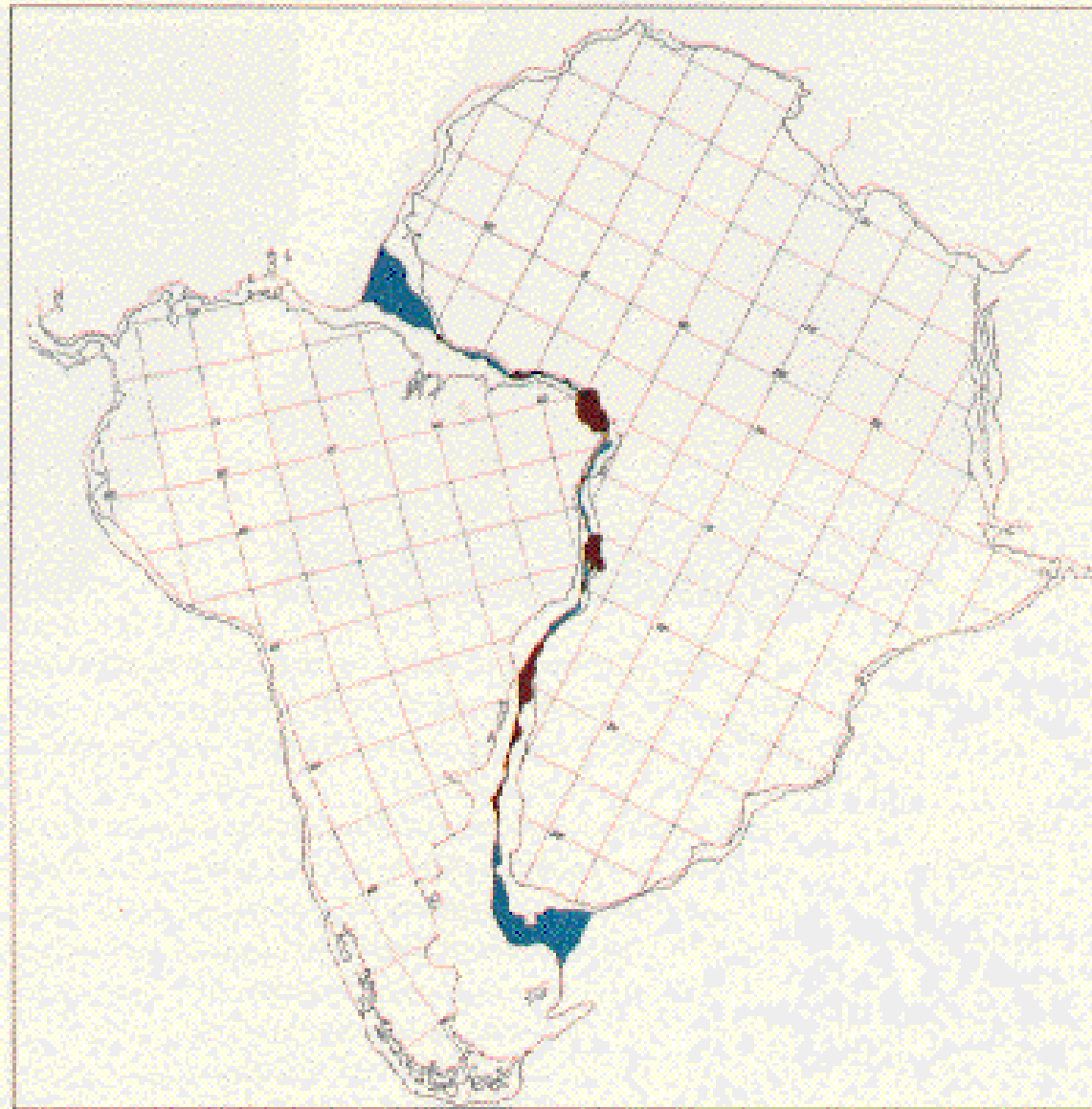
(b) Events at plate boundaries

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# Plate Tectonics

- Seafloor Spreading is the Mechanism for Plate Tectonics
  - As plates move over the asthenosphere, they carry the continents embedded within them.
    - This idea was first suggested by a German scientist Alfred Wegener in 1915.
    - He suggested the theory of *Continental Drift*, based on the congruity of the shapes of the continents across the Atlantic Ocean
    - He also looked at shapes of both South America and Africa and theorized that the shapes of the two continents fit as if they once were one.
    - In the late 1960's this theory was finally accepted when seafloor spreading was discovered
-

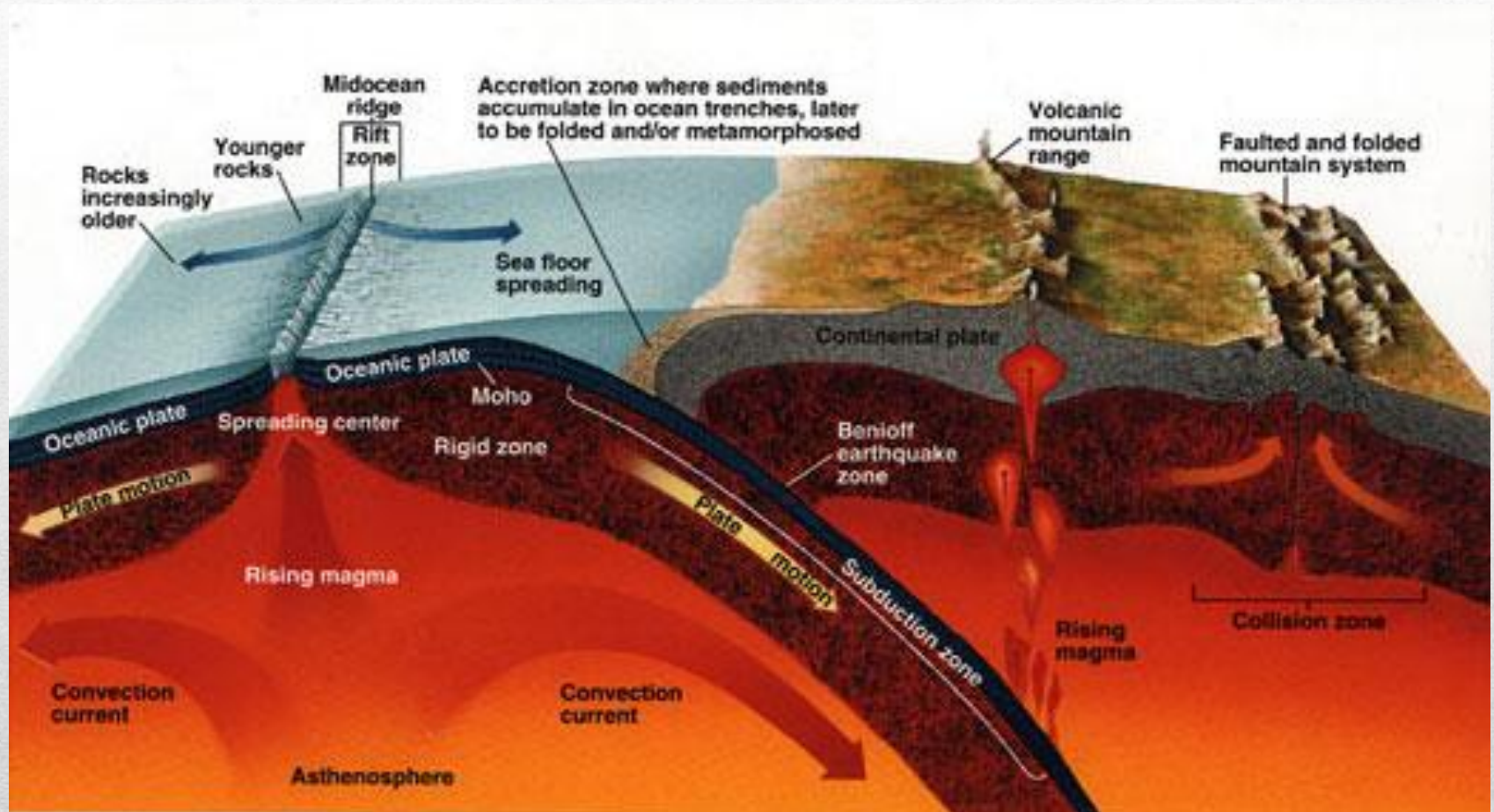




# Seafloor Spreading is the Mechanism for Plate Tectonics

- Mid-oceanic Ridges or Spreading Centers are continuously adding to the edges of the lithosphere
  - The other edges of the lithospheric edges are being destroyed at Subduction Zones around the Earth
  - Continents do not move *through* oceanic crust; they are carried along with it with the movement of the plates
  - Because of the creation of lithosphere at the Ridges is balanced by the consumption of the lithosphere at Subduction Zones
  - The Earth remains constant, neither growing nor shrinking
-

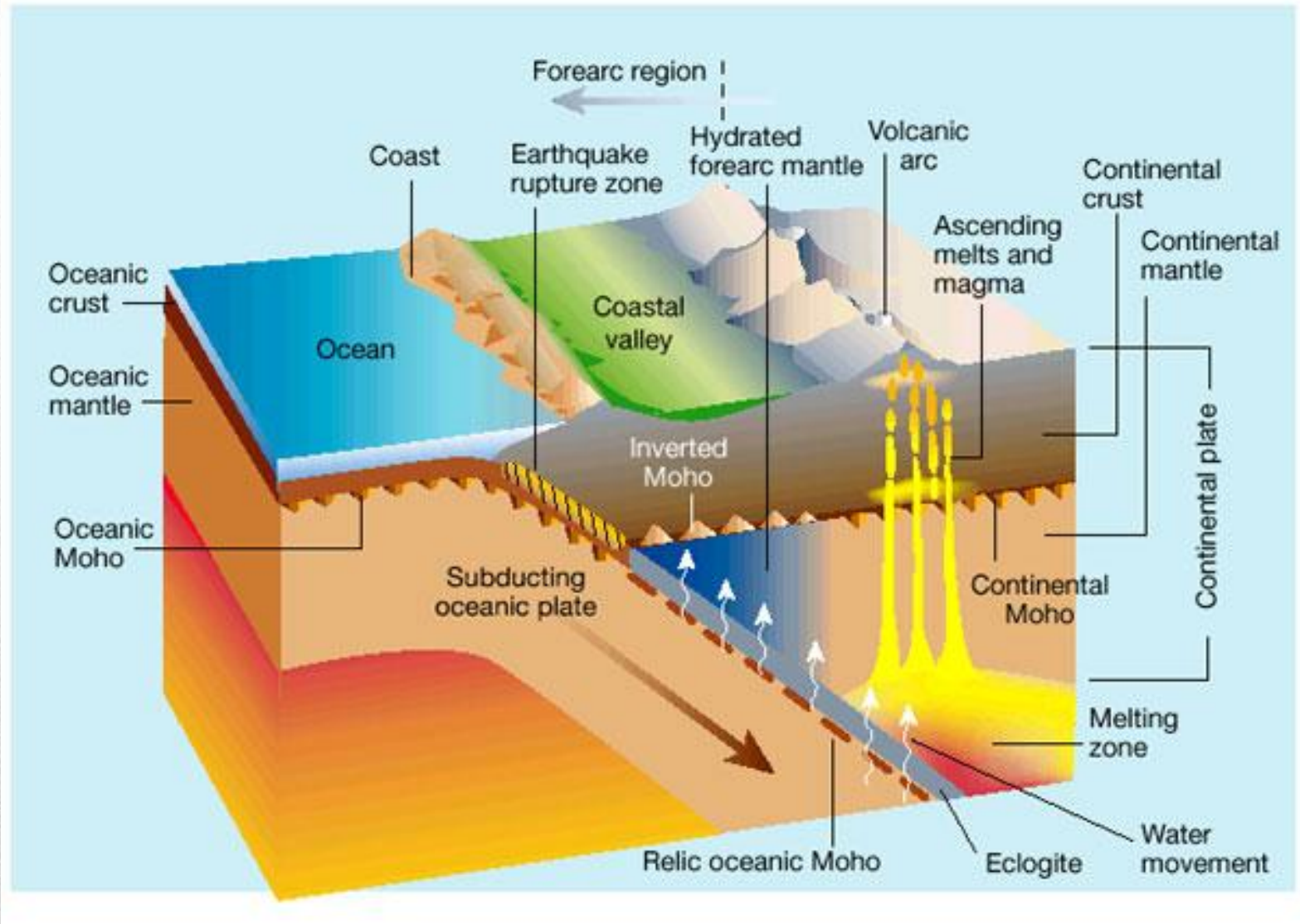




# Sinking Plates Generate Earthquakes

- How do sinking plates generate earthquakes and volcanoes
    - When cold wet ocean crust is subducted under the continental crust, it comes in contact with the asthenosphere, creating magma
    - The magma begins to rise, the continental crust is pushed up and volcanoes are formed
    - Earthquakes occur when the relatively cooler sinking lithosphere comes in contact with the hot asthenosphere
    - This contact causes the rock to cool and crack, causing earthquakes
  - Plate Tectonics is the Unifying Theory for geology
    - It explains an enormous variety of phenomena
-





# Types of Plate Boundaries

- There are three types of Plate Boundaries
- **Divergent Boundaries**
  - Where neighboring plates are pulling apart
  - New Lithosphere is released here expanding the ocean floor
  - These are ocean ridges or continental riffs
  - Examples are the Atlantic Ocean Ridge or the Red Sea Riff





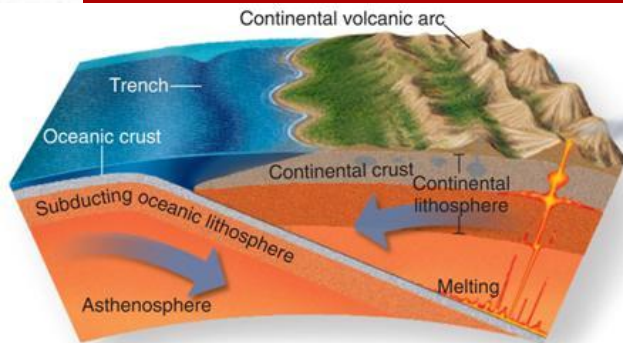
# Continental and Ocean Floor Rocks

- Continental crust consists mostly of granite
    - Less dense
  - Ocean crust consists mostly of basalt
    - More dense
  - Ocean crust is subducted under the continental crust
-

# Types of Plate Boundaries

- Convergent Boundaries
  - These are where plates merge together
  - There are three basic convergent boundaries
    - Ocean-Continental Boundaries – Ocean plate subduct under the Continental Crust
      - Creates –**trenches, volcanoes** – Chilean Mountains and Trench
    - Ocean-Ocean Boundaries – Older Ocean plate subduct under the newer Ocean plate
      - Creates – **volcanic islands, submarine trenches**- Japan and Mariana Trench
    - Continental-Continental Boundaries – no subduction happens, uplift occurs
      - Creates- **mountain ranges**- Himalayan Mountains
-

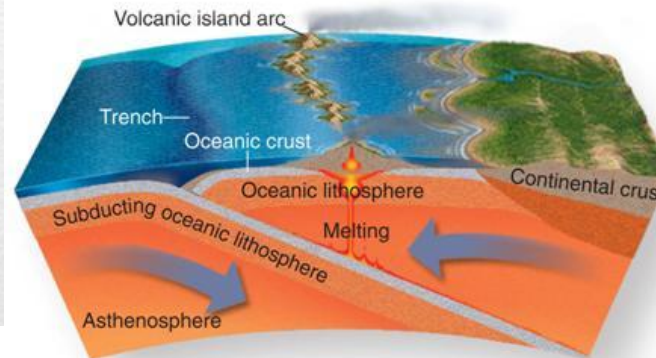




**Oceanic-Continental Boundary**  
When oceanic and continental plates converge, the oceanic plate must subduct beneath the continental plate because the density of thick continental crust is too low to permit it to sink into the asthenosphere.

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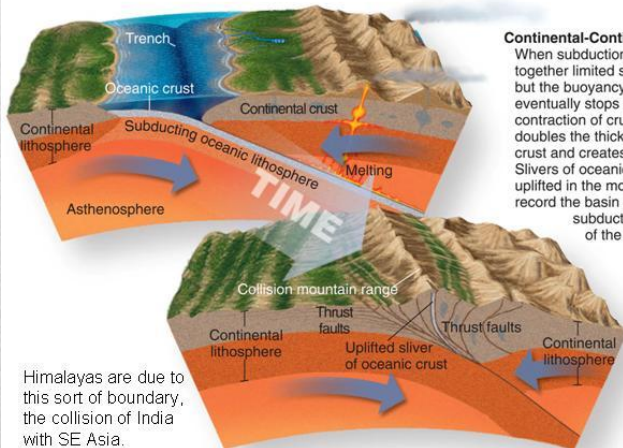
**Fig 12.26**



**Oceanic-Oceanic Boundary**  
When a convergent boundary forms between plates of oceanic lithosphere, the plate that is older, thicker, and denser subducts the less dense plate.

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**Fig 12.26**



**Continental-Continental Bound.**  
When subduction brings two continents together limited subduction may occur, but the buoyancy of continental crust eventually stops the subduction. The contraction of crust in the collision zone doubles the thickness of continental crust and creates high mountains. Slivers of oceanic crust are commonly uplifted in the mountain range and record the basin consumed by subduction prior to collision of the continents.

Himalayas are due to this sort of boundary, the collision of India with SE Asia.

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**Fig 12.26**

# Transform Boundaries

- Or a Transform Fault
  - Where the edges of two plates slide past each other
  - Contains a series of riffs (spreading) along the fault
    - Best known- San Andreas Fault in California
    - Causes many earthquakes
    - San Francisco on its way to the Gulf of Alaska
-

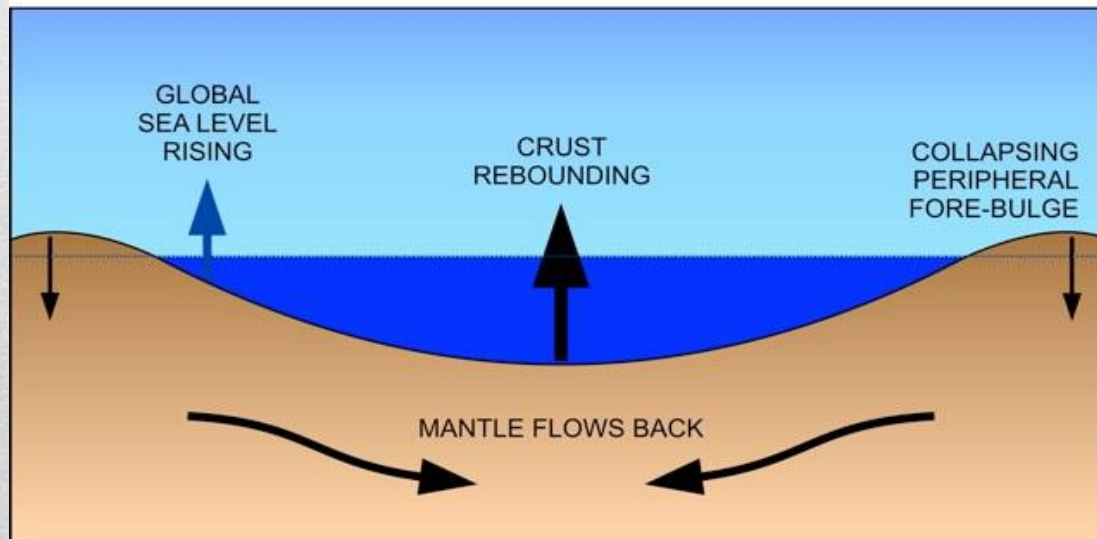
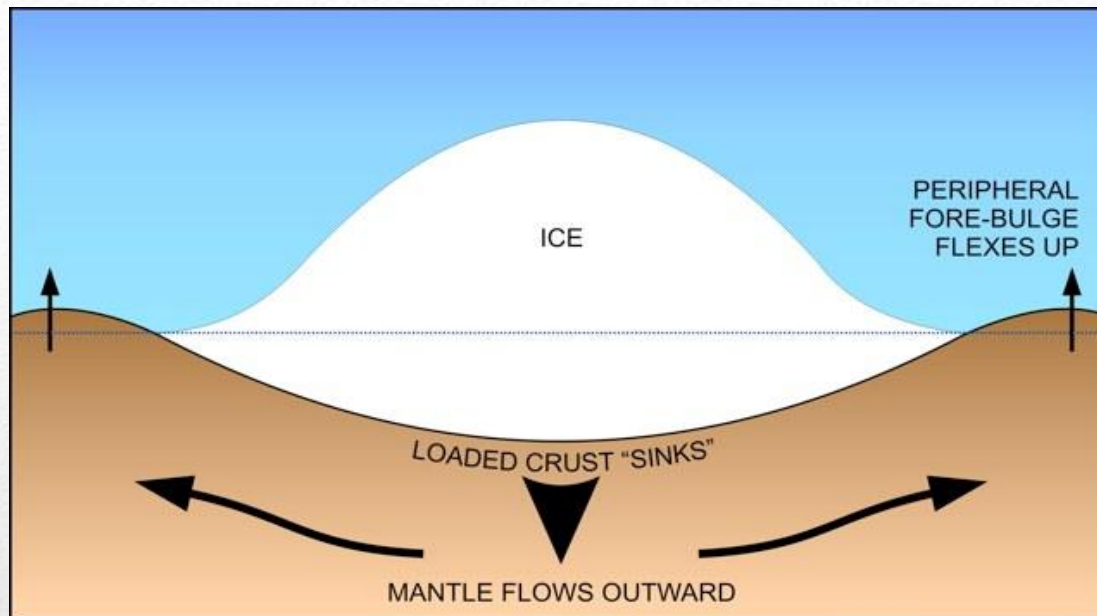




# Isostasy

- The crust is floating on the denser, deformable mantle below
  - Questions:
    - How deep is the sinking of the crust?
    - What determines the areal extent of an isostatic adjustment?
    - What is the immediacy of the isostatic response?
-



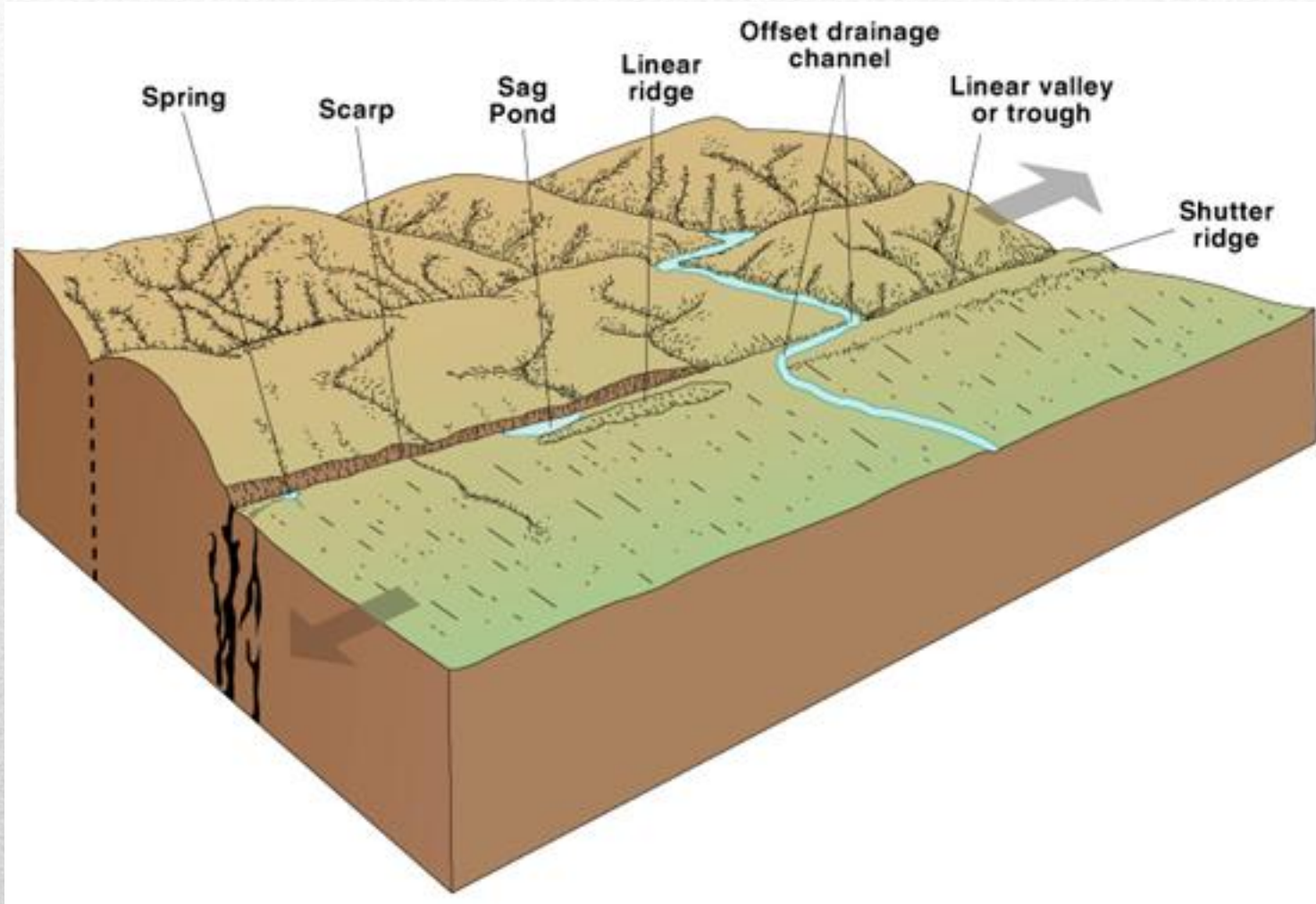


# **Rates of Plate Motion**

- **Plate Motion is a Fast Geologic Process (comparatively)**
  - **Plates move a few centimeters per year (about as fast as your fingernails grow)**
  - **This can cause some features, streams or rocks to be displaced over time where the feature crosses the fault**
-



# Landform from Transform Faults



# Detailed Look at Seafloor Spreading

- By the 1950's the theory of Continental Drift accepted
    - Supported by depth soundings
    - Found seamounts/ridges or trenches
  - Seafloor spreading
    - 1960's new theory- by Harry Hess and Robert Dietz
    - Mechanism for continental drift, mid ocean ridges form from rising mantle creating ridges, spreading the ocean floor
    - Verified by the Paleomagnetism—reversal of pole magnetism
-



# Sea Floor Spreading

- The Validity of Seafloor Spreading from three sources:
    - Identification and mapping of the oceanic ridges
    - Dating of volcanic rocks on the floor of the ocean
    - Understanding and mapping the paleomagnetic history of the ocean basins
  - Paleomagnetism
    - Study of Paleomagnetism history helps to understand sea floor spreading and plate tectonics
    - Because of the convection processes within the earth, the Earth has experienced periodic magnetic reversals.
    - This produces magnetic “stripes” in the iron bearing minerals found on the earth’s floor
  - New crust is formed and returned to the mantle every 200 million years
- 

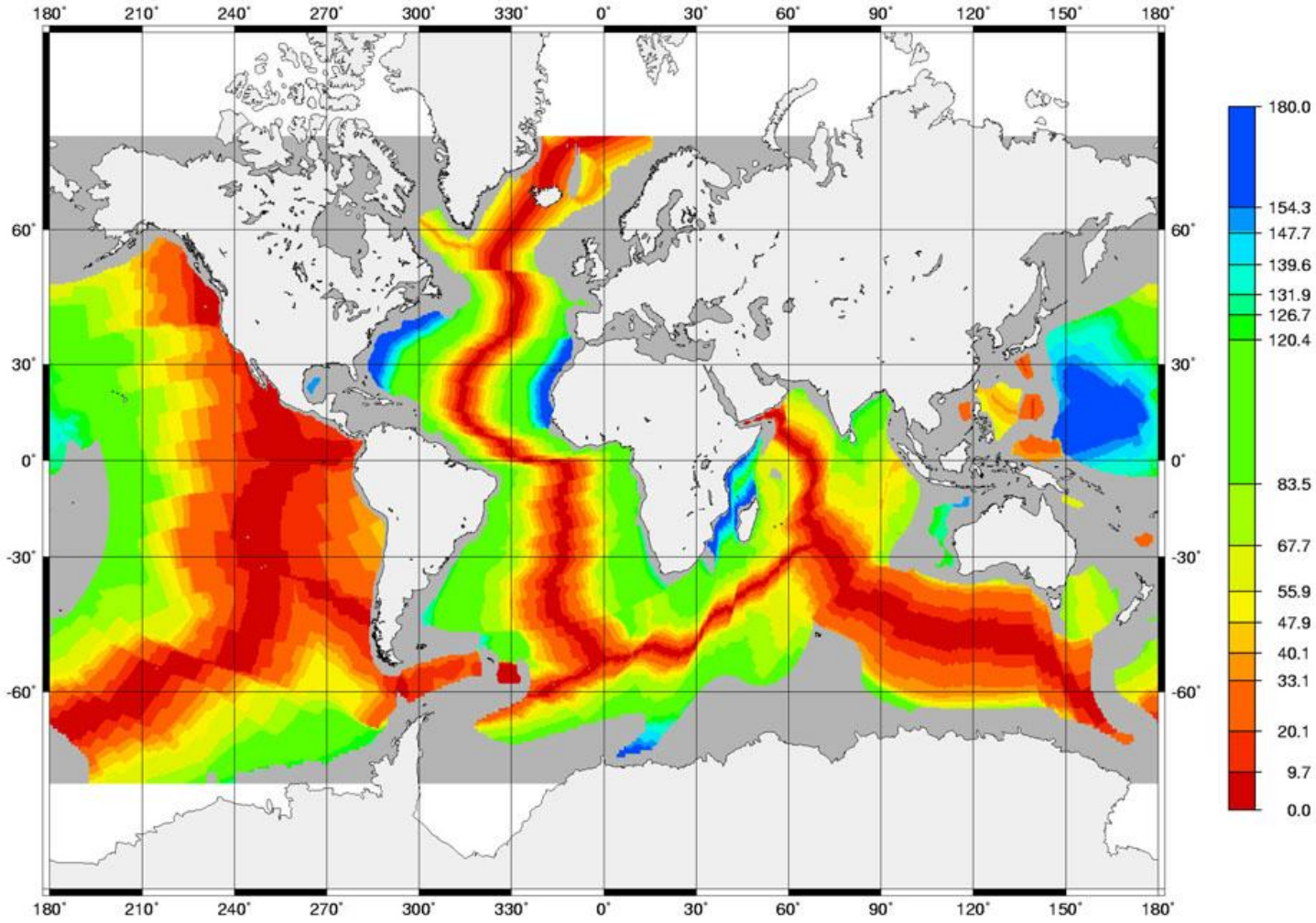


## SCIENTIFIC SPECIALTY: GEOCHRONOLOGY

Seafloor age in millions of years

This map is from Dietmar Mueller, Univ. of Sydney

This map is part of "Discovering Plate Boundaries," a classroom exercise developed by Dale S. Sawyer at Rice University (dsawyer@rice.edu). Additional information about this exercise can be found at <http://terra.rice.edu/plateboundary/>.

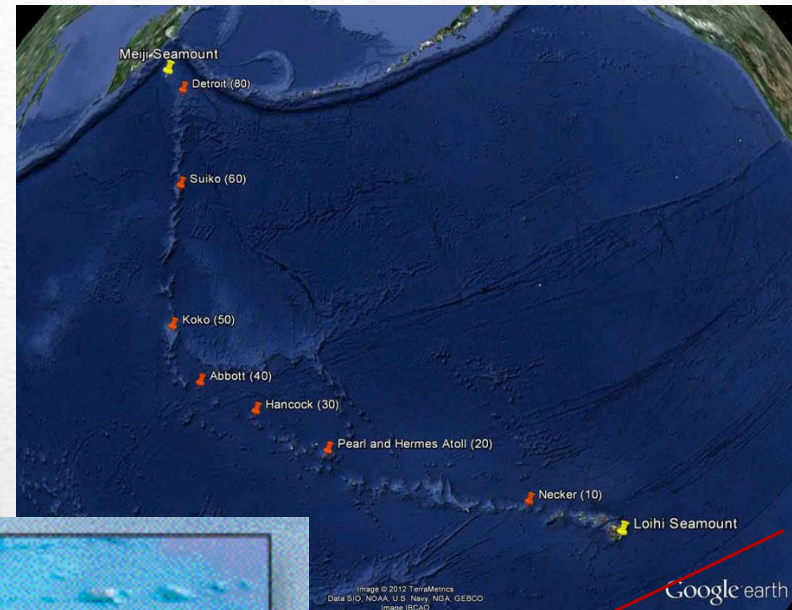




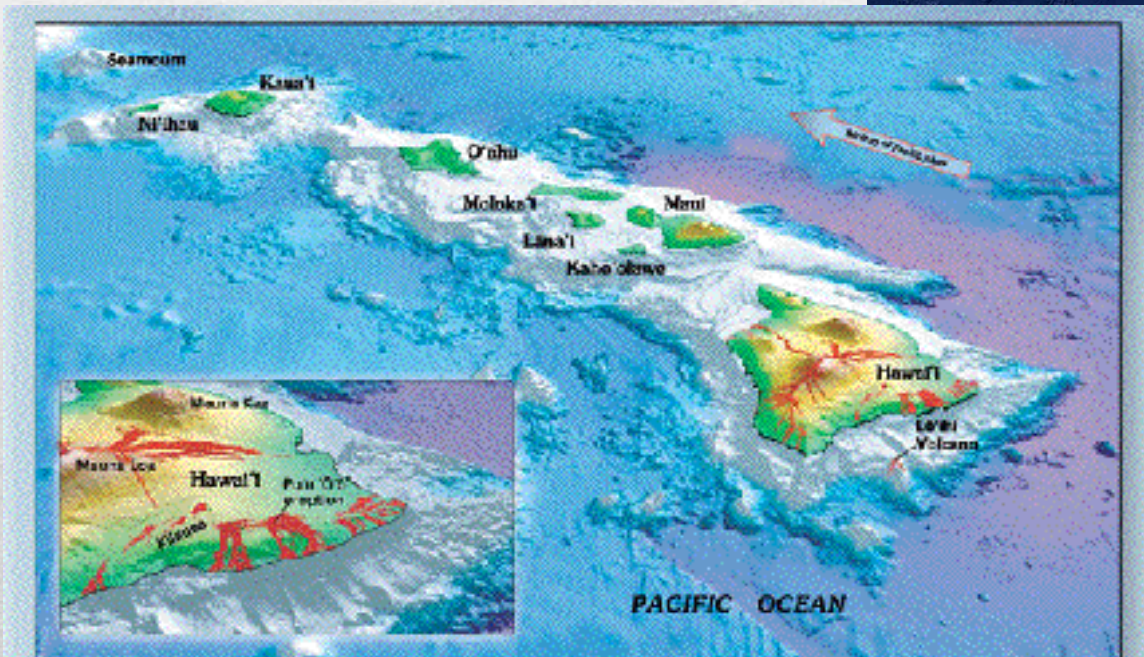
# Hot Spots

- Spots of volcanic activity caused by a thin Earth's crust allowing the magma to move to the surface
- These are called **Hot Spots or Mantle Plumes**
- Hawaii and Yellowstone are known Hot Spots
- As the plate moves across the Hot Spot, a **trail is left, such as the Hawaiian Island archipelago**
- These islands are called *seamounts*
- **Hot Spots help to explain volcanic activity in the middle of plates and help to distinguish the direction of the plate's movement.**





New  
Island



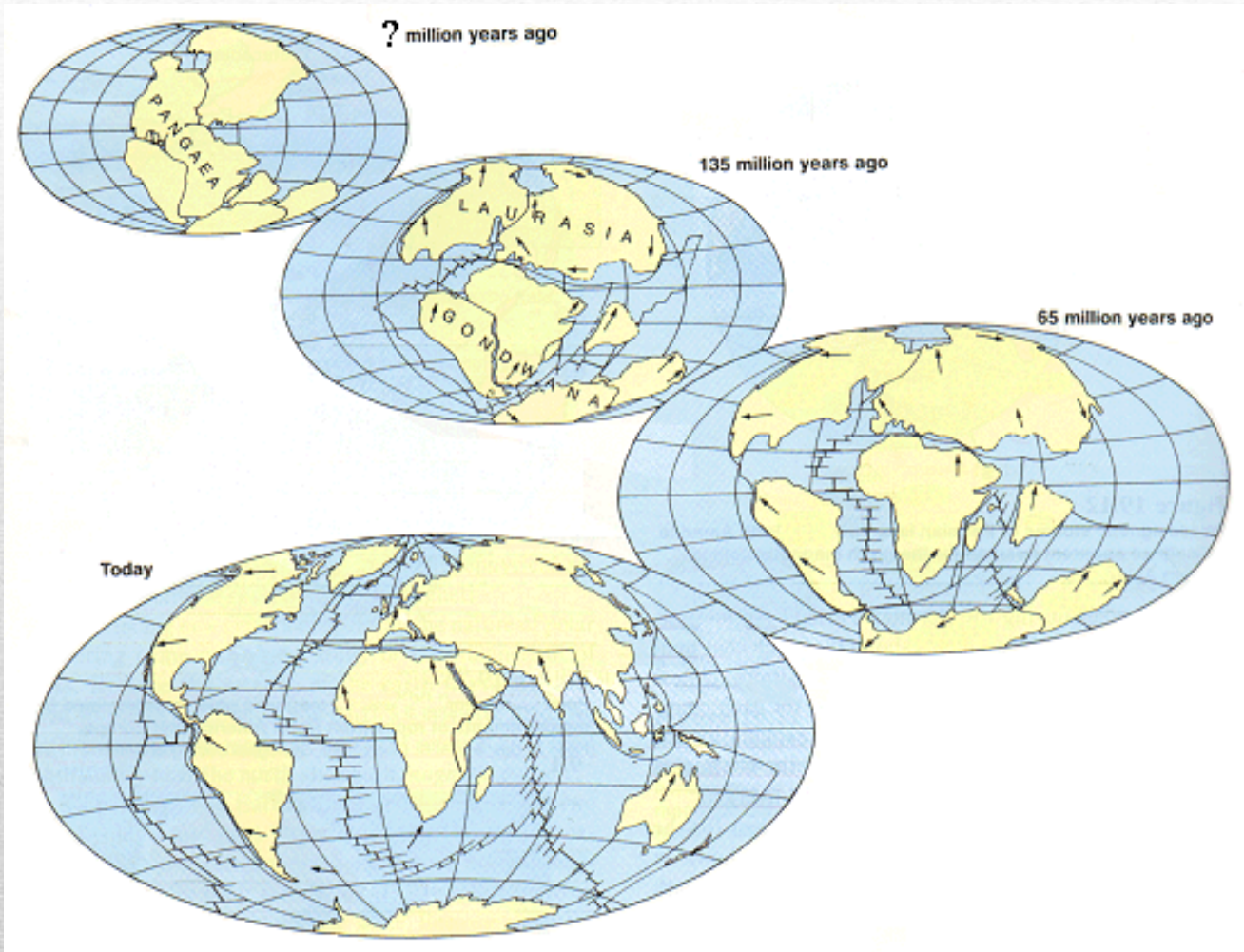


# Pangaea and Present Continents

- Summary of the time line
    - 450 million years – 5 continents- merged together to form Pangaea
    - Next 200 million years; one continent
    - 200 million years – Pangaea starts to break up– Laurasia/Gondwanaland- then to even smaller pieces
    - 135 million years -- North and South Atlantic Oceans begin to open, separating South America and Africa, Mediterranean Sea began to close as Africa began to rotate northward toward Asia
    - 65 million years --North and South Atlantic Oceans joined; South America was new Continent and moving westward, Andes growing, as South America overrides the Pacific Plate. Rockies were rising but not the Sierras
-



Pangaea



Pangaea begins to break apart into present continents



# Assembly & Breakup of Pangaea

- “Today” South America connected to North America
- North America separated from Europe
- Europe, Australia has split from Antarctica
- India collided with Eurasia-thrusting up the Himalayas
- All continents are still in motion except for Antarctica
- Africa is splitting along Great Rift Valley rotating counterclockwise



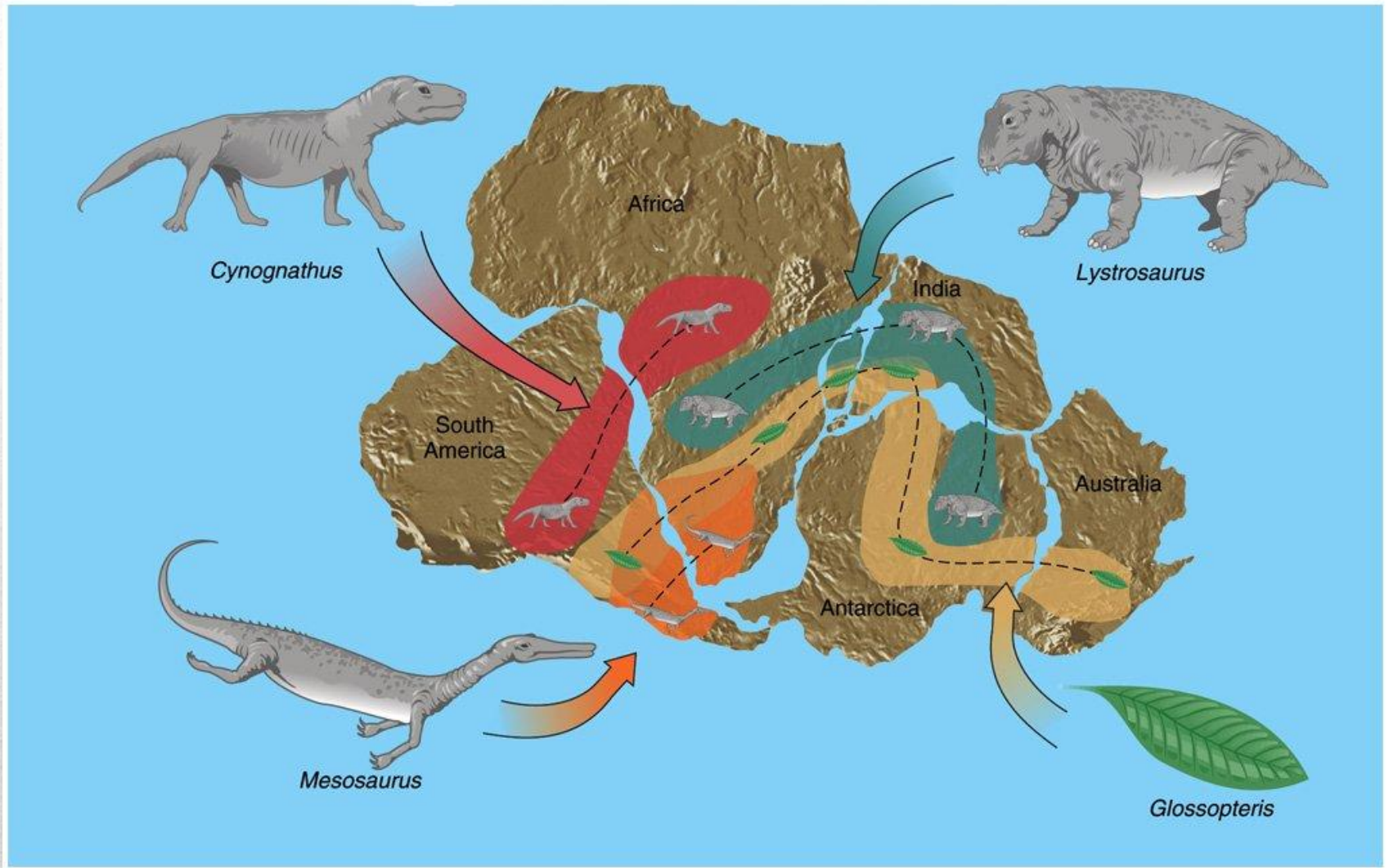
# Future of the continents

- 50 million years from now
    - Australia will straddle the equator is huge tropical island
    - Africa may pinch the Mediterranean shut
    - East Africa becomes large island like Madagascar
    - The Atlantic will widen while the Pacific will shrink
    - Southern California, now a chilly island will pass San Francisco heading for its ultimate destination in the Aleutian Trench of the Gulf of Alaska
-



# Understanding Plate Tectonics Solves Long-Standing Geologic Problems

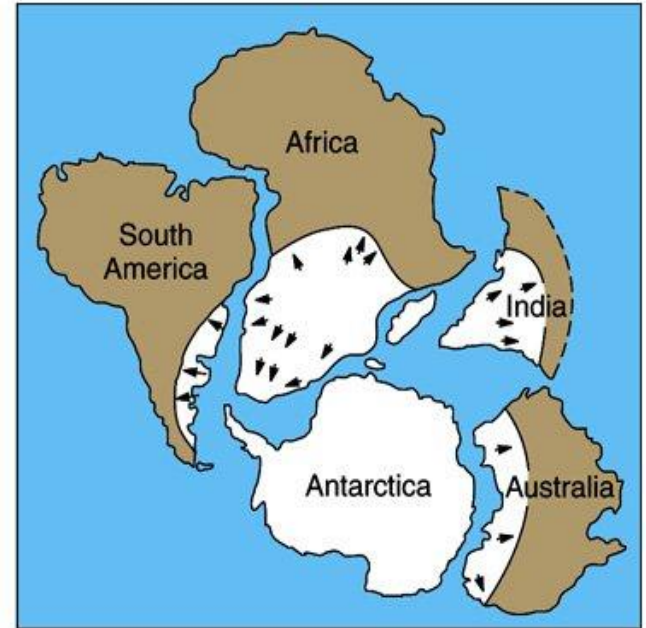
- Understanding Plate Tectonics helped to clear up two geological problems:
    - How did fossils of the same animals and plants end up in both South America and Africa
    - Evidence of ancient glaciation on several continents with inferred directions of ice flow were the same as if there was only one continent
-







A

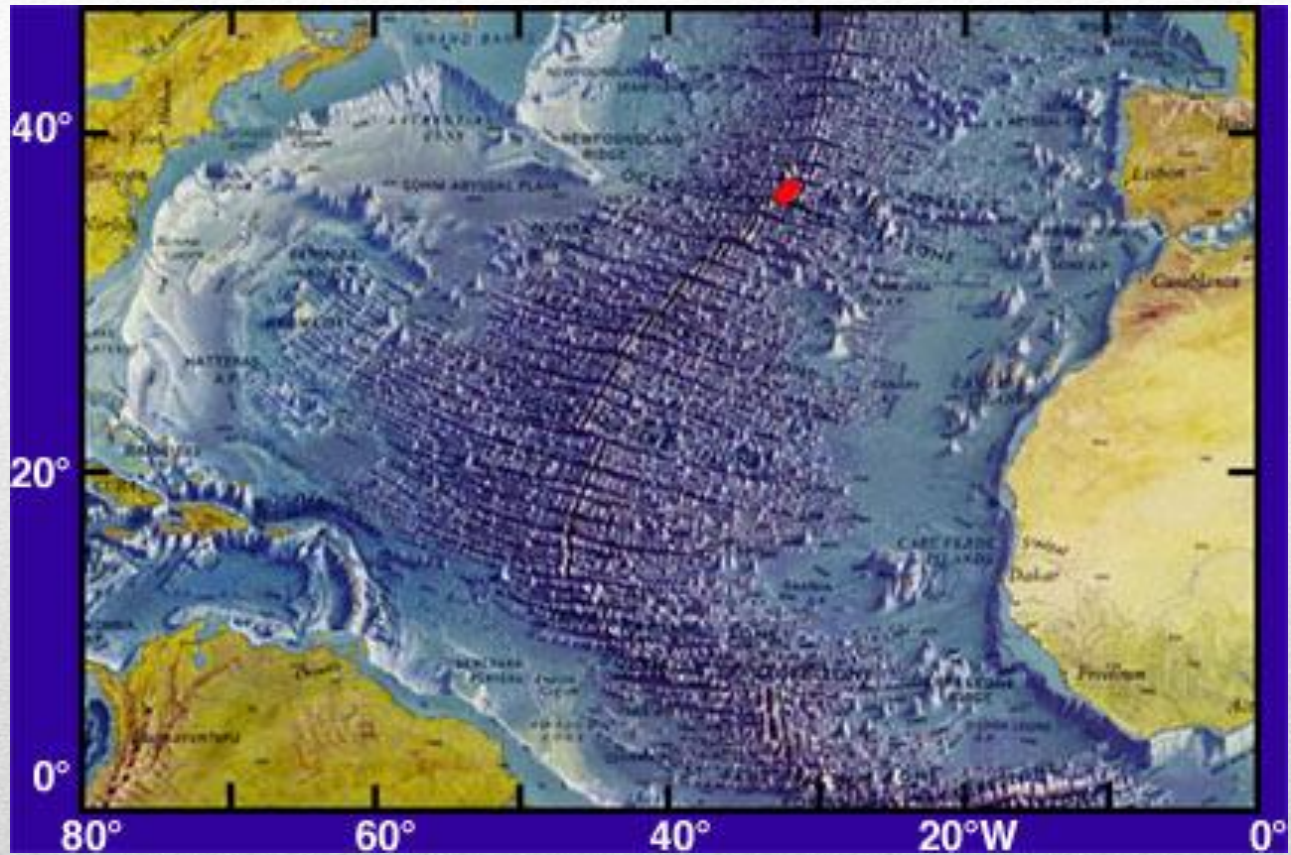


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# How Plate Tectonics Works: Putting it Together

- **Driving Mechanisms that move the plates**
    - This could be call a “push me pull me” method
    - The mid ocean ridge pushes new magma up creating new ocean floor, moving the old crust outward
    - The old crust moves outward from the mid-ocean ridge
    - As this happens this crust pushes the lighter continental plates over the asthenosphere
    - The continental plate move until it hits another plate.
    - Depending on the plate, there will be a subduction or a collision, with either volcanoes or trenches built or huge mountain ranges
    - Convection in the mantle and asthenosphere guarantee this process will continue
-





# Plate Tectonics and Hazards

- Plate Tectonics Affect Us All
    - The *Linkages* of plate tectonics to hazards is obvious
    - Where plate boundaries are located volcanoes and earthquakes are mapped
    - Other conclusions are:
      - Divergent boundaries can be associated with volcanoes if land is associated,
        - Example: Iceland
      - Transform boundaries – earthquake hazards are intensified, and where mountains are found landslides and flooding may be experienced
      - Convergence Boundaries cause many hazards
        - Mountainous areas have landslides and flooding
        - Volcanoes and earthquakes can be expected
    - Plate Tectonics are associated with the natural hazards found around the world
    - Man only makes the hazards worse
-